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Open File Report 89-36

INDUSTRIAL MINERAL PRODUCTION AND CONSUMPTION

IN NEW BRUNSWICK

VOLUME 1

INDUSTRIAL MINERALS USED PRIMARILY

IN THE FERTILIZER INDUSTRY

by

ADI Limited
Fredericton, New Brunswick



Canada-
New Brunswick
Mineral
Development
Agreement

Entente Canada-
Nouveau-Brunswick
L'Exploitation
Minérale



Natural Resources and Energy
New Brunswick

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PREFACE

From 1985-1989, the Province of New Brunswick, in conjunction with the Government of Canada, has initiated a number of mineral commodity studies through the Economic Development Program established under a Federal-Provincial Mineral Development Agreement. An important part of this agreement has involved studies designed in part to provide important marketing information on selected industrial minerals. These market-related projects have tended to concentrate on potential market growth areas primarily in North America, and particularly in areas where a New Brunswick producer could be competitive.

Whether it be building stone from Shediac, gypsum from Hillsborough or limestone from Saint John, industrial minerals have historically been important contributors to the economic growth and prosperity of New Brunswick. Today, industrial minerals are still important. Potash mining generates millions of dollars of salaries and business in the Sussex area, while the processing of phosphate rock with by-product sulphuric acid from a nearby lead smelter is a major industry in the Belledune-Bathurst region.

Preliminary figures for the value of industrial mineral production in New Brunswick was about \$251 000 000 (Cdn) in 1988 compared to \$197 000 000 in 1987. This represents an increase of twenty-two (22) percent. In 1988, industrial mineral production accounted for 31 percent of the total value of Provincial mineral production.

The manufacturing sector of the Province and surrounding areas consume substantial quantities of industrial minerals and their derived chemicals. Changing technology is making new demands on both the quality and quantities of industrial minerals consumed in the region. The requirement to document industrial mineral production in the Province as well as the consumption of these mineral commodities both, in the Province and adjacent areas, is becoming an increasingly important facet of responsible resource management.

Keenly aware of the importance of industrial minerals, the New Brunswick Department of Natural Resources and Energy has sponsored a review of industrial mineral supply and demand for New Brunswick (exclusive of granular and bedrock aggregate). The review was conducted under contract by ADI Limited and Three-D Geoconsultants Limited.

The purpose of the study is to provide as comprehensive and contemporary information as possible concerning the state of the industrial minerals industry in New Brunswick from both a producer's and consumer's point of view. Towards the achievement

of this goal, an assessment of the current supply/demand situation in the Province and adjacent, reasonably accessible market areas was undertaken in an attempt to identify potential opportunities for market expansion and future development of indigenous industrial mineral resources. Another study objective is to indicate to various manufacturing industries where sources of various industrial mineral products are located in New Brunswick. Such an approach may be of some value in attracting new manufacturing industries to the Province. In addition, an attempt has been made to identify and document local market opportunities by showing producers where, in what quantities, and under what circumstances industrial minerals and industrial mineral-based chemicals are being utilized within the Province and immediate surrounding areas.

Although this study focused primarily on the supply and demand of industrial minerals and industrial mineral-based chemicals produced and consumed in New Brunswick, the demand for similar projects in market areas considered reasonably accessible to a local producer were also considered to some extent.

The results of the review were issued in the spring of 1989 and consist of a six-volume report. Volumes 1, 2 and 3 detail the history of specific industrial mineral production and consumption in New Brunswick and current demand within a market-place easily accessible from the Province. Volume 4 provides demand projections for key industrial minerals, and describes the possible effects on future demand from environmental, technical, and other developments. Finally, Volumes 5 and 6 include a directory of New Brunswick's mineral producers and of industrial mineral consumers within economic shipping distances of New Brunswick.

Component volumes of this extensive study are listed below:

<u>Volume</u>	<u>Title</u>	<u>Open File Report</u>
1.	Industrial Minerals Used Primarily in the Fertilizer Industry	89-36
2.	Industrial Minerals Used Primarily in the Construction Industry	89-37
3.	Industrial Minerals Used Primarily in the Chemical and Pulp and Paper Industries	89-38
4.	The Future of Industrial Minerals: General Trends in Consumption and Transportation	89-39
5.	Directory of New Brunswick Industrial Mineral Producers	89-40

<u>Volume</u>	<u>Title</u>	<u>Open File Report</u>
6.	Directory of Consumers of Industrial Minerals in Eastern Canada and the Northeastern United States	89-41

This volume addresses those selected industrial minerals consumed primarily in the fertilizer industry - potash, sulphur and phosphate rock.

VOLUME 1

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PHOSPHATE ROCK

PHOSPHATE ROCK

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PHOSPHATE ROCK

1.0 INTRODUCTION

Definition. Phosphate rock is a term applied to any rock containing significant quantities of phosphate minerals. The most common phosphate mineral in nature is fluorapatite ($\text{CaF}_2 \cdot 3\text{Ca}_3(\text{PO}_4)_2$), which is extremely insoluble.

Phosphate rock is graded in one of two ways:

- phosphorus pentoxide (P_2O_5) equivalent
- tricalcium phosphate of lime ($\text{Ca}_3(\text{PO}_4)_2$) equivalent, also known as TPL or bone phosphorus of lime (BPL).

One unit of P_2O_5 is equal to 43.6 percent phosphorus and is equivalent to 2.18 units of TPL. (PR 1, PR 2)

Special properties. All living things contain phosphorus and require phosphorus to live. Phosphorus is used to transfer and store energy within the organism and has a key role in the metabolic process. Phosphate rock, like potash (see Potash) is a key mineral for fertilizer production.

Phosphorus compounds are used to promote fire retardancy in textiles and to control forest fires. Phosphorus is a key ingredient in many soaps and detergents. Many insecticides and pesticides use phosphorus chemicals. (PR 3, PR 4)

2.0 PRODUCTION STATUS IN NEW BRUNSWICK (PR 1, PR 7)

Even though phosphatic rocks are known to occur in New Brunswick, it is not mined in the Province (or in Canada). The Brunswick Mining and Smelting Corp. Ltd. (Fertilizer Division) currently imports about 270 000 tonnes per year of phosphate rock. The material arrives at their Belledune operation in northern New Brunswick by sea from Florida.

The fertilizer plant at Belledune treats imported phosphate rock (more properly this is a beneficiated ore) with excess sulphuric acid (H_2SO_4) generated at the nearby BMS smelter in what is termed a wet-acid process. Phosphoric acid is produced as an intermediate stage in the process and this is reacted with ammonia to produce diammonium phosphate. The Belledune operation made a conversion in 1986 from the dihydrate process to the hemihydrate process which results in substantial energy savings. The process is under license from Norsk-Hydro Fertilizers. The plant conversion was designed by Société de Prayon and built by Wellman Power Gas Inc. at a cost of about \$4 million.

Diammonium phosphate or DAP has an NPK (where N is the percent elemental nitrogen (N), P is the phosphate content (P_2O_5), and K is the potash content (K_2O)) ratio of approximately 18-46-0 and is sold mainly to fertilizer blending plants in the Maritimes, Quebec and Maine.

Monoammonium phosphate with an NPK ratio ranging from 16-48-0 to 11-48-0 has also been produced.

For every tonne of phosphoric acid produced in the process, about 3 tonnes of waste phosphogypsum is also produced. This material contains some impurities which were originally present

in the phosphate rock and are concentrated by the processing. In some cases, these impurities can be economically recovered. In the southeastern United States and California, some phosphogypsum is used as a soil conditioner (land plaster). The Belledune operation has investigated several options for utilization but has not developed a viable market for this material.

3.0 CONSUMPTION

Uses and quantities. All phosphate rock consumed in Canada is imported, over 90 percent from the United States (70 percent from Florida, the rest from Idaho, Montana and Utah). In turn about two-thirds of the phosphate rock is used for fertilizer production, one-third for elemental phosphorus production.

In the United States, 19 percent of phosphate rock is exported, 75 percent is used for fertilizer, 5 percent for elemental phosphorus and 1 percent for other uses (see Table 1 and Figure 1).

3.1 Fertilizer

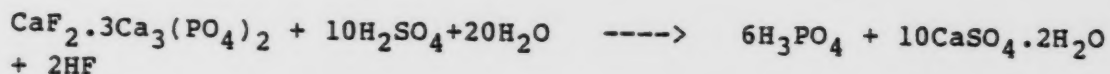
Description. Some phosphate rocks are sufficiently reactive that they can be crushed, ground and applied directly to farm fields. This material would provide slow-release phosphorus.

Most fertilizers, however, require a much more reactive form of phosphorus: **phosphoric acid, normal superphosphates, or triple superphosphate.** These materials then serve as ingredients in the production of blended fertilizers.

Most phosphoric acid is produced from phosphoric rock using the wet process with sulphuric acid. The key reactions are:

phosphate rock + sulphuric acid + water yields phosphoric
acid + gypsum + hydrogen fluoride

or in chemical terms:



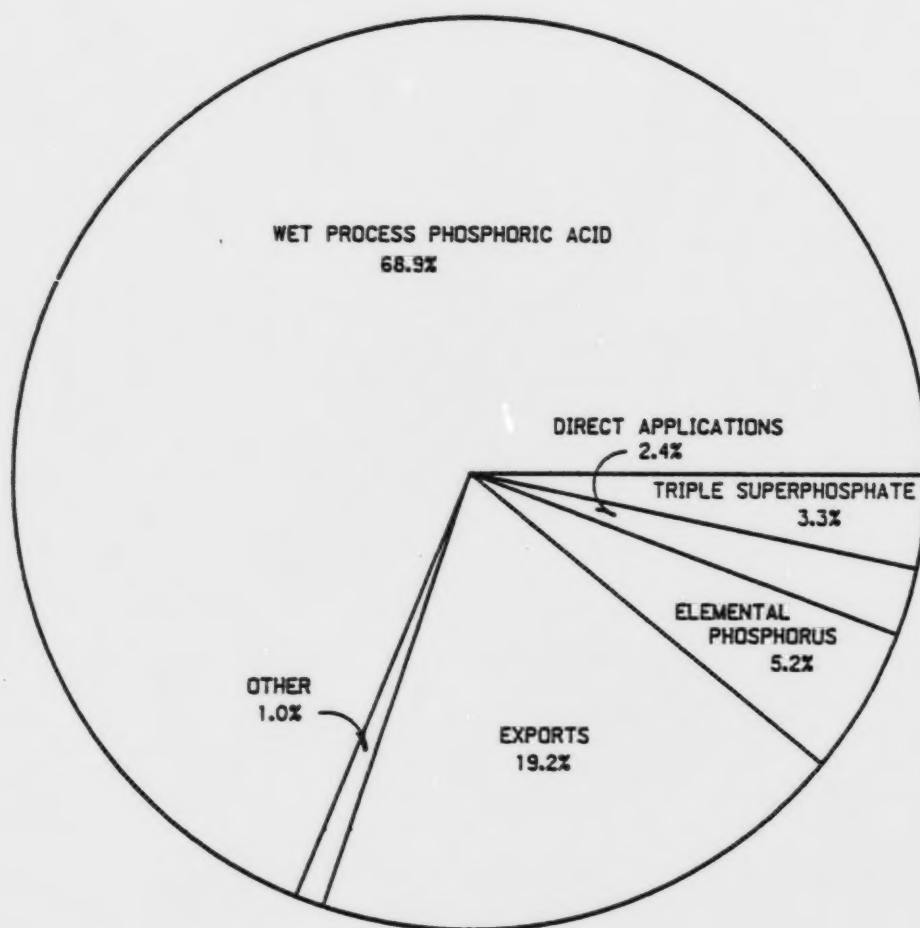
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TABLE 1

PHOSPHATE ROCK SOLD OR USED BY PRODUCERS
IN THE UNITED STATES BY USE - 1986 (PR 5)

Use	Consumption	
	Tonnes (M)	%
Domestic: Wet process phosphoric acid	25.4	68.9
Normal superphosphate	0.2	0.5
Triple superphosphate	1.2	3.3
Defluorinated rock	0.1	0.3
Direct applications	0.9	2.4
Elemental phosphorus	1.9	5.2
Ferrophosphorus	*	**
Total	29.8	80.8
Exports	7.1	19.2
TOTAL	36.9	100.0

FIGURE 1
CONSUMPTION OF PHOSPHATE ROCK IN THE
UNITED STATES, IN 1986 (PR5)



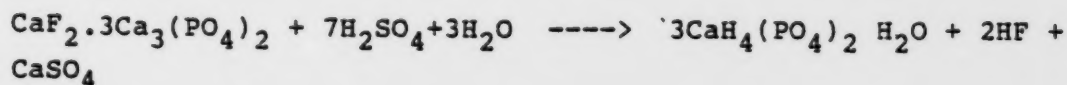
The phosphoric acid, in turn, is used to produce high-analysis fertilizer, triple phosphate, and ammonium and dicalcium phosphates. Pure phosphoric acid for non-fertilizer chemicals is produced using the electric-furnace process with elemental phosphorus.

In Canada most fertilizer is produced from phosphoric acid which is neutralized by ammonia producing either diammonium phosphate (DAP, 18-46-0) or monoammonium phosphate (MAP, 11-48-0 to 11-55-0):

Normal superphosphate is also produced using sulphuric acid but in lower concentrations:

phosphate rock + sulphuric acid + water yields monocalcium phosphate + hydrogen fluoride + anhydrite

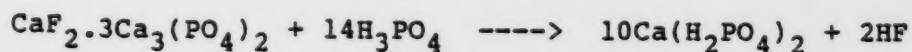
or in chemical terms:



An alternative production method uses nitric acid or a mixture of sulphuric and nitric acids. Nitric acid adds nitrogen (another important nutrient) to the fertilizer product.

Superphosphate has 16-20 percent available P_2O_5 .

Triple superphosphate is a very concentrated source of phosphorus with 44-51 percent available P_2O_5 . It is made by treating phosphate rock with phosphoric acid yielding triple phosphate and hydrogen fluoride:



Companies and locations. Belledune Fertilizer, a division of Noranda Inc., is the only Canadian consumer of phosphate rock for fertilizer within 800 kilometres of New Brunswick. Located at Belledune, N.B. the plant has an annual capacity of 0.150 M tonnes of phosphate rock per year. The plant produces diammonium phosphate using Florida phosphate rock and sulphuric acid and sulphur dioxide from a nearby lead smelter.

There are no known plants producing phosphoric acid, normal superphosphate, or triple phosphates in the United States within 800 kilometres of New Brunswick. Most American producers of phosphates for fertilizer are located near the sources of phosphate rock, that is Florida, North Carolina and other southeastern states and Idaho, Wyoming and other mountain states.

Sources and suppliers. The phosphate rock for Belledune Fertilizer is supplied from a Hillsborough County, Florida minesite (the Lithia mine) operated by Hopewell Land Co., a subsidiary of Noranda Inc. The mine can supply 0.45 M tonnes per year. The rock is shipped by boat to Belledune, N.B.

Other large phosphate rock suppliers in the United States are:

Agrico Mining Co.	- Florida
W.R. Grace & Co.	- Florida
Occidental Petroleum Corp.	- Florida, Tennessee
USS Agri-Chemicals	- Florida
Stauffer Chemical Co.	- Idaho, Tennessee
Texasgulf Inc.	- North Carolina
Monsanto Co.	- Idaho

Specifications. In Canada, all the dihydrate wet phosphoric acid fertilizer plants are designed to use phosphate rock of 69-72 percent BPL (Bone Phosphate of Lime - 31-33 percent P_2O_5). A common standard for such plants is to have $Fe_2O_3 + Al_2O_3 + MgO$ concentration less than 10 percent of the P_2O_5 concentration of the rock. The plants usually recover 88-94 percent of phosphate input.

Prices. Phosphate rock prices in the United States for 1986-1987 are given in Table 2. Prices (\$Cdn) for phosphate products in July 1988 (PR 7) were:

Phosphate rock, Florida, land pebble run of mine washed, 66-68 percent BPL, bulk carload, mines	\$33.95/tonne
vessel, Tampa	\$41.05/tonne
Phosphoric acid, commercial and technical grades, 75 percent, tanks, f.o.b. freight equalized	\$675/tonne
80 percent tanks, f.o.b. freight equalized	\$720/tonne
85 percent tanks, f.o.b. freight equalized	\$775/tonne

Substitutes. Phosphorus is an essential nutrient, there is no substitute for it. Other than phosphorus-bearing slag there is no substitute for phosphate rock as a source of phosphoric acid and phosphatic fertilizers. (PR 1)

3.2 Elemental Phosphorus

Description. Elemental phosphorus is used for a wide variety of chemicals. Most of these chemicals fall into one of four categories:

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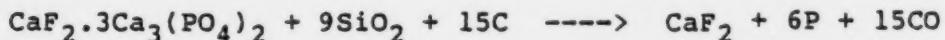
TABLE 2

AVERAGE PRICES (\$CDN/TONNE) FOR
PHOSPHATE ROCK IN THE UNITED STATES, 1986-1987 (PR 6)

Grade	Period	
	July 1 - Dec. 31, 1986	Jan. 1 - June 30, 1987
+74% BPL	\$37.35	\$38.75
72-74	32.05	31.75
70-72	31.25	30.65
66-70	26.90	25.85
60-66	27.70	24.65
-60	33.40	37.35
Average	28.15	26.75

- 1) water treatment and detergents (phosphorus salts remove lime and magnesia from water thereby softening it as well as they help to emulsify and disperse solids when used in detergents);
- 2) food and medicine;
- 3) phosphate esters* (esters are important components of solvents, plasticizers, monomers, medicines, and perfumes); and
- 4) miscellaneous uses.

It is produced by the electric furnace method using the furnace energy to convert phosphate rock, silica, and coke to calcium fluoride, phosphorus, and carbon monoxide:



Companies and locations. There is one Canadian company producing elemental phosphorus within 800 kilometres of New Brunswick: Tenneco Canada Inc., ERCO Division's plant in Long Harbour, Newfoundland. The capacity of the plant is 0.060 M tonnes/year of elementary phosphorus produced from Florida phosphate rock (about 0.365 M tonnes per year). Most of the production is shipped to Europe for use in phosphorus chemicals.

There are no known elemental phosphorus plants in the United States within 800 kilometres of New Brunswick. As for fertilizers, most elemental phosphorus plants in the United States are located close to the phosphate rock source.

*An ester results from a combination of an alcohol and an organic acid. Esters have pleasant smells and tastes and are found (natural and artificial) in many foods, perfumes, medicines, etc.

Specifications. For the production of elemental phosphorus a lower grade of phosphate rock (60-67 percent BPL) is used rather than that used for the production of phosphoric acid (69-72 percent BPL). The higher level of impurities aids in the formation of flux in the electric furnace.

Prices. See Fertilizer (Section 3.1).

Substitutes. See Fertilizer (Section 3.1). For most phosphorus chemicals substitutes are not possible. However, for soaps and detergents concerns over phosphorus pollution (a primary cause of algae blooms) has lead to the development of several substitute emulsifiers including polyelectrolytes, ziolites (sodium aluminum silicates), surfactants, NTA (nitrilotriacetic acid), and sodium silicate.

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POTASH

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POTASH

1.0 INTRODUCTION

Definition. Potash is a generic term covering a number of potassium salts including potassium chloride (also known as "muriate of potash"), potassium magnesium sulfate, potassium sulfate, potassium nitrate, and potassium-sodium mixture. Other minor members of the potash group are potassium oxide (ceramicists potash), potassium carbonate (the original potash), and potassium phosphate.

Potassium chloride (KCl) is the most common form of potash and usually sold as 95 percent pure. Potash is evaluated as K_2O equivalent by stoichiometric analysis, thus KCl has a K_2O equivalence of about 60 percent (P1).

Special properties. Potash is a key agricultural fertilizer because of its potassium content. Potassium, in turn, has these important horticultural properties:

- 1) it aids in the production of starch and sugar;
- 2) it stiffens straw in cereal crops;
- 3) it promotes root growth; and
- 4) it strengthens plants against disease and adverse climate.

For industrial uses, potash serves as an important source of potassium (P1).

2.0 PRODUCTION STATUS IN NEW BRUNSWICK

Since the 1840s saline springs have been known to occur near the Town of Sussex. In 1954, a group of geological prospectors stumbled on a small salt spring close to the town. The discovery was interesting, but there were already several salt mines in the Atlantic Provinces, and another one might have been more than the market could support.

A sample of the spring water was analyzed and indicated not only the presence of a potentially large sodium chloride (salt) body in the area, but also traces of potassium chloride (potash). Though potash is more valuable than salt, it was not thought to be present in large enough quantities for mining. (P5)

For fourteen years, the New Brunswick Department of Natural Resources tried to attract investors without success, in part due to unstable potash markets. In 1969, the Department approached the newly formed Federal Department of Regional Economic Expansion (DREE). DREE agreed to fund the cost of 10,000 feet of drilling up to a maximum of \$185,000. The program was designed to confirm the existence of high grade salt near Sussex for a potential chemical industry west of Saint John.

Early in 1971 two diamond drill holes, Plumweseep No. 1 and Penobsquis No. 1 were drilled by the New Brunswick government. Although high grade salt was encountered in both holes, it was in the Plumweseep hole that the first significant intersection of potash was discovered. In that hole an aggregate of 20 metres of potash in the form of sylvinite, 23.7 percent K_2O equivalent in average grade was encountered. It was later discovered that the other hole had missed the potash zone by a relatively short distance.

Following this initial discovery of potash, the New Brunswick government removed all the rights for potash and related minerals from the traditional prospecting and staking procedure under the Mining Act. They opted in favour of inviting companies to bid on exploration and subsequent development rights for selected potash reservation areas.

Following the success of the first government drilling program, three additional drill holes were initiated in 1973 all in the vicinity of Sussex. This program resulted in the discovery of two additional potash/salt occurrences in the Salt Springs/Cassidy Lake area and at Lower Millstream. Proposals were also invited for the exploration and development of these sites. In 1973, the Potash Company of America, Inc. was awarded the rights to the Penobsquis deposit. In 1976 the International Minerals and Chemicals Corp. obtained the rights to the Cassidy Lake deposit but subsequent transactions resulted in the Denison-Potacan Potash Company being assigned the rights. In 1981 BP Exploration Canada Ltd. (Selco Division) was awarded the rights to the Lower Millstream deposit. The history of each development is reviewed individually below.

The Potash Company of America (a Division of Rio Algom Limited) Subsequent to receiving the rights to the Penobsquis deposit, the Potash Company of America (PCA) conducted a surface exploration program that included a total of 36 drill holes. This program was conducted between 1973 and 1976. In 1977 a mining lease with the New Brunswick government was approved. In 1978 it was decided to proceed with underground exploration and construction of an exploration shaft was undertaken. In the course of the completion of this development phase, salt was produced and marketed. A decision, based on the results of the underground exploration, to proceed with development was announced in 1980. The mine and mill became operational in

1983. The potash is mined using the "cut and fill" method in which the "roof" of the working zone is extracted and the waste rock, or tailings from the milling process, is returned underground to the mine "floor" to build up the floor of the mined area allowing mining machines to make another pass along the "roof". However, excess tailings remain and cannot be stock-piled on surface since they readily dissolve and would represent a potential environmental problem. Despite the fact that these tailings are composed primarily of salt, they are not of suitable quality to have market acceptability. PCA's method of dealing with this situation is to mine high quality salt from another zone of the deposit and market this material. The resultant cavity is used for tailings and excess brine disposal. (See Salt section of this report.)

The potash ore is crushed underground and brought to surface to the mill where the potash is separated from the waste material. The product is then shipped by rail to Saint John for shipment by sea to various markets. The first potash shipments made by PCA were in 1984 through newly constructed facilities at Courtenay Bay.

In 1986, PCA's parent company, Ideal Basic Industries Inc. of Colorado, sold PCA's Canadian operations (including an operating mine in Saskatchewan) to Rio Algom Limited of Toronto.

The Denison-Potacan Potash Company Deposit at Salt Springs

The International Minerals and Chemical Corp. (IMC) acquired the rights to the Salt Springs (also called Cassidy Lake or Clover Hill) deposit in 1976. In 1979 IMC assigned the rights to the deposit to Denison Mines Ltd. In 1980, Denison assigned a 40 percent interest in the venture to Potash Company of Canada (Potacan). Potacan is 50 percent owned by Enterprise Miniere et Chimique of France and 50 percent by Kali und Salz AG of

Germany. The Denison-Potacan Potash Company is operated and managed by Denison with the other partners responsible for sales.

By 1978 a surface exploration program had completed 25 drill holes. A mining lease was approved in 1978 and sinking of an exploration shaft commenced in 1979. Underground exploration was conducted in 1982 and a decision to proceed with production was announced in 1983. The mine commenced production in 1985. A twenty kilometre rail spur line was constructed to connect with the main Sussex to Saint John line to enable shipment of product through the Courtenay Bay terminal in Saint John.

The ore is mined using a room and pillar method with a combination of drill and blast techniques and continuous mining machines to extract the ore. The ore is brought to surface and the potash extracted at the mill. Tailings are to be returned to the "rooms" left underground.

The BP Resources Canada Ltd. (Selco Division) Deposit at Lower Millstream

BP Resources Canada Ltd. (Selco Division) (formerly BP Exploration Canada Ltd.) acquired the rights to the Lower Millstream deposit in 1981. A surface exploration program consisting of 11 drill holes was conducted between 1981 and 1984. A pilot hole for an exploration shaft has been drilled but a decision to proceed with further evaluation by shaft sinking and underground exploration has not been announced. A mining lease with the New Brunswick government was signed in 1985.

Table 1 provides statistics on Provincial royalty revenues for potash production.

TABLE 1

ROYALTY REVENUE*: NEW BRUNSWICK POTASH PRODUCTION (P9)
1981-1988

<u>Year</u>	<u>Current Dollars Thousands</u>	<u>Constant 1987 Dollars Thousands</u>
1981	20.375	28
1982	166.160	195
1983	-	-
1984	363.338	412
1985	1344.399	1525
1986	2927.262	3044
1987	4260.394	4260
1988	7384.899	7090

*Royalty revenue based on 6-1/4% of the selling price of standard grade potash product.

2.1 Derived Products

Potassium sulphate (K_2SO_4) can be produced from potassium chloride (KCl) by a number of methods. A recent study (P6) conducted on behalf of the Province reviews ten methods of manufacture. One of the principal requirements for the various processes is a source of sulphur. These can include sulphuric acid, gypsum, and sulphur dioxide. The report recommends two processes for further study.

About 4 to 5 percent of the world's total production of potash takes the form of potassium sulphate. The commodity commands a premium price and is not favored by farmers since potassium chloride generally gives equivalent yields at a lower price. However, in certain circumstances potassium sulphate is the only viable fertilizer. Certain crops, such as tobacco and, to a lesser extent potatoes, and citrus fruits, are sensitive to chloride ions in the soil. In countries where saline soils are prevalent, the addition of further chloride is undesirable. Potassium sulphate also favorably increases sulphur levels in soils.

The market for potassium sulphate for tobacco farming appears to be declining but longer term consumption on other crops is expected to increase (P6). Markets for 30,000 tonnes of product from a "development plant" appear accessible in eastern Canada and the eastern U.S. However, a commercial plant producing 100,000 to 200,000 tonnes per year would have to access export markets and would have limited competitive advantages over existing producers in Europe. There are no current plans to proceed with potassium sulphate production in the Province.

Several other products which are produced from salt, e.g., chlorine, can also be produced from potash and are reviewed in the salt section of this report.

3.0 CONSUMPTION

Uses and quantities. Canada is a major exporter of potash; in 1985 total production was 6.637 M tonnes of which 6.203 M tonnes (93.5 percent) was exported. The exports went to the United States (67.1 percent of exports), Japan (5.8 percent), Indonesia (5.0 percent) and twenty-nine other countries. Production in 1987 was reported at 6.4 M tonnes with exports to the United States at 3.3 M tonnes and elsewhere, 2.6 M tonnes (P2, P4).

Domestic consumption was 0.434 M tonnes in 1986. Of that figure, 0.410 M tonnes (94.5 percent) was used by agriculture and 0.024 M tonnes (5.5 percent) for industry (see Figure 1).

The United States is a large importer of potash (P2). In 1986 it consumed 8.200 M tonnes of material of which 6.934 M tonnes (84.6 percent) was imported. Of United States consumption in 1986, 93.8 percent was muriate of potash (KCl). Of muriate consumption, in turn, 92.9 percent was for agricultural uses and 7.1 percent for nonagricultural purposes (P3).

The nonagricultural uses of potash are based upon the supply of potassium for such products as television tubes, storage batteries, rubber products, soaps and detergents, greases, pharmaceuticals, chocolate, and as a salt-substitute. The potash (KCl) is converted to potassium hydroxide by aqueous electrolysis prior to most industrial use (P1):

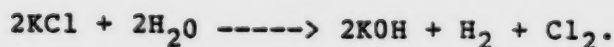
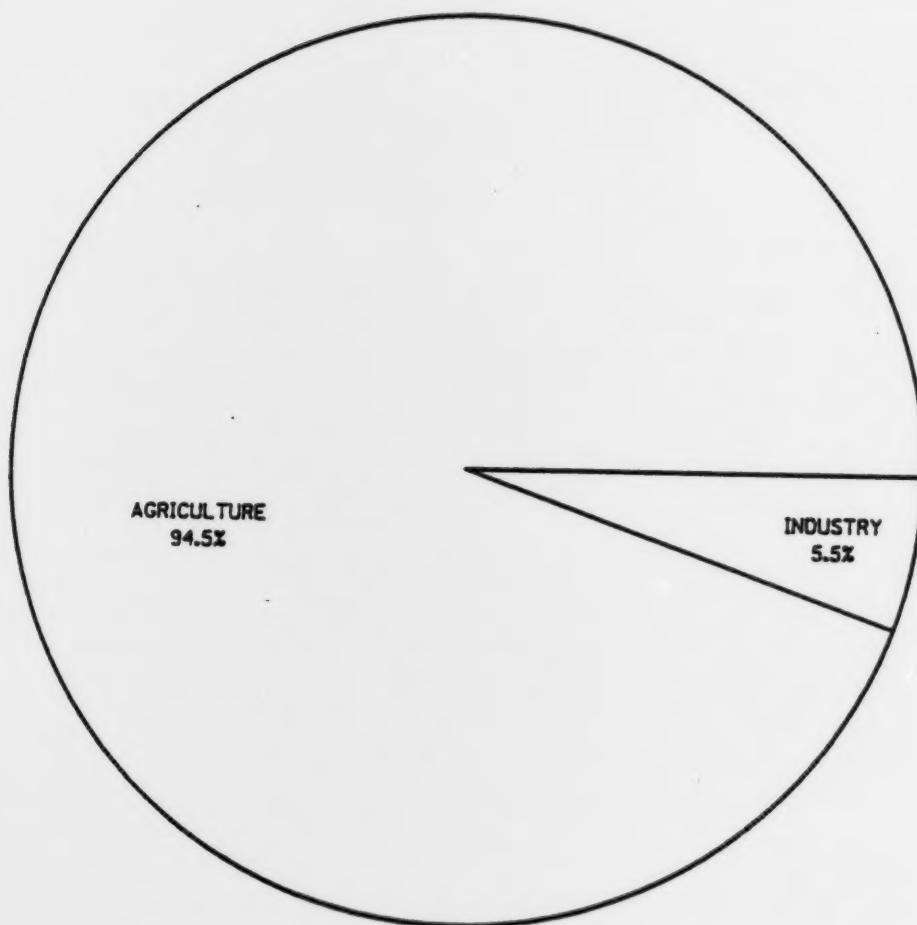


FIGURE 1

CONSUMPTION OF POTASH IN CANADA
IN 1986, (P2)



3.1 Fertilizer

Description. Each of the major potash salts will be discussed separately.

- Muriate of potash (KCl), also known as MOP, represents over 90 percent of potash production and consumption in Canada and the United States. Pure MOP is 63.2 percent K_2O equivalent; in commerce MOP is sold in grades of 60 percent, 50 percent, 40 percent, and 30 percent K_2O equivalent.

An important consideration in MOP production is grain size. It is important to match potash grains to the grain size of other fertilizer ingredients (diammonium phosphate, for example) to prevent differential settling of ingredients.

The quantity of MOP in a fertilizer mix depends upon the application (some crops require mixtures lean in potassium) and the form of fertilizer (granular, solution, suspension). Solution fertilizers can contain up to 11 percent K_2O equivalent where suspension fertilizers can contain up to 32 percent K_2O equivalent.

In 1986, American consumption of potash was 29.7 kilograms of K_2O equivalent per hectare.

- Sulphate of potash (K_2SO_4), also known as SOP, represents about 5 percent of fertilizer use of potash. It is preferred to MOP on chloride-sensitive crops such as tobacco, grape, potato, sugar beet, and citrus fruits.
- Potassium nitrate (KNO_3) and langbeinite ($2\text{MgSO}_4 \cdot \text{K}_2\text{SO}_4$) are also used for agriculture but in small amounts.

Sources and suppliers. There are only two producers of potash within 800 kilometres of New Brunswick and both are within the Province (Table 2).

By potash type the main North American producers are presented in Table 3.

Companies and location. Most potash is not applied directly to farmland but blended with other nutrient sources to provide a balanced nitrogen-phosphorus-potassium mixture (NPK). The blend depends upon the soil conditions (what is available naturally) and crop requirements. Blending is done by fertilizer manufacturers. They are usually relatively small operations serving an agricultural district.

Table 4 presents the names and location of large fertilizer producers within 800 kilometres of New Brunswick.

Specifications. The main specifications for potash are potassium content, as measured by K_2O equivalence, and grain size. Table 5 presents the specifications for chemical grades of potash.

Prices. In the last three years potash prices have experienced substantial fluctuations in prices (Table 6).

Within the United States prices fell steadily from 1984 to 1987. Table 7 presents the f.o.b. mine prices for United States potash sold within that country (in Cdn dollars).

TABLE 2

PRODUCERS OF POTASH WITHIN 800 KILOMETRES OF NEW BRUNSWICK (P2)

<u>Province/State</u>	<u>Company</u>	<u>Location</u>	<u>(M tonne/year)</u>	<u>Note</u>
New Brunswick	Potash Company of America (Rio Algom Limited)	Penobsquis	0.380	miriate of potash
	Denison-Potacan Potash Company	Cloverhill	0.790	miriate of potash

TABLE 3

NORTH AMERICAN PRODUCERS OF POTASH, BY TYPE (P1, P3)

Type	Province/State	Company and Mine Location
Muriate of potash (MOP)	New Brunswick	Potash Company of America: Penobsquis
		Denison-Potacan Potash Company: Cloverhill
	Saskatchewan	Potash Corp. of Saskatchewan: Allan, Cory ¹ , Rocanville, Esterhazy, and Lanigan
		Central Canada Potash (a subsidiary of Noranda Inc.): Colonsay
		International Minerals and Chemical Corp.: Esterhazy
		Kalium Chemicals: Belle Plain
		Cominco Ltd.: Vanscoy
		Potash Co. of America ² : Patience Lake
		Kidd Creek Potash Co.: Allan
	New Mexico	Eddy Potash Co. (formerly PCA/Lundberg Industries): Carlsbad
		AMAX Potash Corp.: Carlsbad
		International Minerals and Chemical Corp.: Carlsbad
		New Mexico Potash Corp. (formerly Kerr-McGee Chemical Corp.): Carlsbad
		Mississippi Chemical Corp. ³ : Carlsbad
Sulphate of Potash (SOP)	Utah	Texasgulf Inc.: Moab
		Reilly Wendover (formerly Kaiser Aluminum and Chemicals Corp.): Wendover
	California	Kerr-McGee Chemical Corp.: Trona
	Texas	Lundberg Industries Ltd.: Dumas
	New Mexico	International Minerals and Chemicals Corp.: Carlsbad

TABLE 3 (continued)

Type	Province/State	Company and Mine Location
Sulphate of Potash (SOP) (cont'd)	Utah	Great Salt Lake Minerals and Chemicals Corp.: Ogden
	California	Kerr-McGee Chemical Corp.: Trona
Potassium-magnesium sulphate	New Mexico	Western AG Minerals (formerly Duval Corp.): Carlsbad
		International Minerals and Chemical Corp.: Carlsbad
Potassium nitrate	Mississippi	Vertac Fertilizers and Minerals Inc.
Manure salts	Utah	Kaiser Aluminum and Chemicals Corp.: Wendover

1. Production of "pink potash product" and potassium sulphate to be scaled down and eventually terminated in 1988.
2. Shutdown in 1987 due to mine flooding.
3. Shutdown as of 1988.

TABLE 4

LARGE FERTILIZER PRODUCERS AND SUPPLIERS
WITHIN 800 KILOMETRES OF NEW BRUNSWICK
(TRADE DIRECTORIES)

Province/State	Company	Location
New Brunswick	Chaleur Fertilizer Ltd. Hartland Agromart Ltd. McCain Fertilizers Ltd. Island Fertilizers	Petit Rocher Hartland Florenceville Salisbury
Nova Scotia	C-I-L Inc. Island Fertilizers Ltd. MacLeod's Feed & Farm Supplies Scotian Gold Co-Op - Valley Fertilizers Div.	Onslow Kentville (Steam Mill Village) Antigonish Kentville (Coldbrook Station)
Prince Edward Island	Malpeque Fertilizers Ltd.	Summerside (Travellers Rest)
Quebec	Agrico Canada Limited Agrocentre Belcan Inc. Centre Agric Co-Op - St. Barthelemy Centre Agricole St. Clet Inc. Co-Op Agricole de la Cote Sud Co-Operative Des Valleees O-L Co-Op Agro-Alimentaire Valleees Co-Operative Federee de Quebec Composts Du Quebec Inc. Engrais Toupin Inc. Fertibec Inc. Gauthier & Tremblay Inc. Lemoine Tropica Canada Inc. Gerard Maheu Inc. Nutrite Inc. Semico Inc. Societie Cooperative Agricole de Montcalm Societie Cooperative Agricole Ste-Rosalie	Chambly Ste-Marthe St-Barthelemy St-Clet La Pocatiere Thurso Thurso La Prairie St-Henri Henryville Ste-Martine Coaticook St-Laurent St-Louis-de-Gonzague Brossard St-Anselme St-Jacques Sainte Rosalie
Ontario	Bradford Fertilizer Limited Harvey Agromat Inc. Lincoln Feed & Farm Supply Nutrite Inc. Plant Products Company Limited Ralph Dale Fertilizers Ltd. Simcoe District Co-Op Services So-Green Inc.	Holland Landing Kemptville Niagara-on-the-Lake Cornwall Brampton Richmond Barrie Markham

TABLE 4 (cont'd)

<u>Province/State</u>	<u>Company</u>	<u>Location</u>
Ontario (cont'd)	United Co-Ops of Ontario	Mississauga
	United Co-Ops of Ontario	Uxbridge
	United Co-Ops of Ontario	Allison
	United Co-Ops of Ontario	Foxboro
	United Co-Operatives of Ontario	Kemptville
	United Co-Operatives of Ontario	Napanee
	Vigoro	Toronto
Maine	Old Fox Chemical Inc.	Leeds
Vermont	Old Fox Chemical Inc.	Lyndon
Rhode Island	Agricultural Products Company	Providence
	Old Fox Chemical Inc.	East Providence
New York	Agway Inc.	Batavia, Genesee Co.
	Crop Production Services Inc.	Newark, Wayne Co.
Pennsylvania	Agway Inc.	Butler, Butler Co.
	Agway Inc.	Clarion, Clarion Co.
	Agway Inc.	Pleasant Gap, Centre Co.
	Agway Inc.	York, York Co.
	Agway Inc.	Dayton, Armstrong Co.
	Agway Inc., Fertilizer Div.	Union City, Erie Co.
	Chemgro Fertilizer Co. Inc.	East Petersburg,
		Lancaster Co.
	Cumberland Valley Co-Op Assn.	Shippensburg,
		Cumberland Co.
	Millardsville Fertilizer Works	Myerstown, Lebanon Co.
	Montgomery-Bucks Farm Bureau Co-Op	Souderton, Montgomery Co.
	Moyer & Son Inc.	Souderton, Montgomery Co.
	Pottstown Roller Mills Inc.	Pottstown, Montgomery Co.
	Reading Bone Fertilizer Co.	Reading, Berks Co.
	Rhoads Mills Inc.	Selinsgrove, Snyder Co.
	Stoltzfus Manufacturing Inc.	Morgantown, Berks Co.
	Van-Mar Feeds Inc.	Shoemakersville, Berks Co.
	York Stone & Supply Co.	York, York Co.

TABLE 5
SPECIFICATIONS FOR COMMERCIAL GRADES OF POTASH (P1)

Grade	Minimum K ₂ O Equivalent	Approximate Particle Size Range ¹		Type of Potash
		Mesh ²	Millimeters	
Granular	61, 50, 22	6- 20	3.35-0.85	Muriate and sulfates
Blend ³	60	6- 14	3.35-1.18	Muriate
Coarse	60	8- 28	2.4 - .6	Muriate
Standard	60, 50, 22	14- 65	1.2 - .21	Muriate and sulfates
Special standard	60	35-150	.4 - .11	Muriate and sulfates
Soluble or suspension	62	35-150	.4 - .11	Muriate
Chemical	63	XX	XX	Muriate

XX Not applicable

1 From approximately 2% to 98% by weight percent cumulative

2 Tyler standard

3 Blend is a new grade with a midpoint between 8 and 10 mesh that is being introduced by Canadian producers

TABLE 6

PRICES FOR POTASH PRODUCED IN CANADA, BY QUARTER (1985-1988)
(ENERGY, MINES AND RESOURCES CANADA)

<u>Year</u>	<u>Quarter</u>	<u>Price, f.o.b. mine \$Cdn/tonne</u>
1985	January-March	95-102
	April-June	95-105
	July-September	94-95
	October-December	83-99
1986	January-March	76-87
	April-June	83-90
	July-September	78-93
	October-December	82-85
1987	January-March	75-77
	April-June	73-83
	July-September	85-97
	October-December	100-114
1988	January-March	109-114

TABLE 7

PRICES¹ OF UNITED STATES POTASH, BY TYPE AND GRADE
(CIN DOLLARS PER METRIC TON OF K₂O EQUIVALENT) (P3)

Type and Grade	1984		1985		1986		1987
	January- June	July- December	January- June	July- December	January- June	July- December	January- June
Muriate, 60% K ₂ O minimum:							
Standard	142	142	136	130	114	102	92
Coarse	154	138	137	116	124	108	116
Granular	154	139	135	105	113	104	98
All muriate ²	149	140	136	118	117	107	103
Sulfate, 50% K ₂ O minimum	499	503	490	453	443	393	395

1 Average prices, f.o.b. mine, based on sales

2 Excluding soluble and chemical muriates

Substitutes. Potassium is an essential nutrient for plants and animals and potash is the lowest cost high concentration potassium source. Thus, potash has no true substitutes, only higher cost, low concentration sources which would be exploited only when cost or availability made potash prohibitive.

Future sources of potash include by-products of chemical or mineral refining processes such as the processing of alunite to alumina.

In many industrial settings sodium and potassium sources are interchangeable with selection dependent upon cost, availability and demand (P1).

3.2 Consumption Estimates

Fertilizer and Nonagricultural Uses. Presented below are sales figures for potash within the extended market area of the Atlantic Provinces, Quebec, and New England:

Province/State	Consumption, thousand tonnes of K ₂ O Equivalent					
	1985			1986		
	Agri.	Nonagri.	Total	Agri.	Nonagri.	Total
Newfoundland	0.373	0.417	0.790	0.245	0.212	0.457
Prince Edward Island	8.281	-	8.281	10.402	-	10.402
Nova Scotia	4.854	-	4.854	3.657	-	3.657
New Brunswick	5.766	-	5.766	15.728	-	15.728
Quebec	112.532	0.176	112.708	86.004	0.434	86.438
Maine	7.010	0.378	7.388	NA	NA	NA
New Hampshire	0.697	0.022	0.718	NA	NA	NA
Vermont	4.572	0.013	4.585	NA	NA	NA
Massachusetts	168.715	1.365	170.080	NA	NA	NA
Connecticut	5.114	0.108	5.222	NA	NA	NA
Rhode Island	2.006	0.084	2.090	NA	NA	NA
Total	319.920	2.563	322.483	-	-	-

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SULPHUR

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1.0 INTRODUCTION

Definition. Sulphur is one of the few elements which can be found in nature in an uncombined or pure state. However, it is much more common in combined form, for example, in gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), hydrogen sulfide (H_2S) or metal sulfides (pyrites). (S2)

Sulphur is an abundant mineral and is used in large quantities for a wide range of applications.

Special properties. Unlike most industrial minerals, sulphur is usually not used as a component of materials but rather as a reagent in material production with the sulphur being retained in the waste product. An example is the production of phosphatic fertilizers from phosphate rock where sulphuric acid is used in the process and becomes part of the gypsum waste product. (S6)

In the United States approximately 80 percent of sulphur is used in the reagent form of sulphuric acid (H_2SO_4). Sulphuric acid is the most popular mineral acid relative to other acids for several reasons:

- 1) lower cost;
- 2) fewer problems in handling, shipping and storage;
- 3) greater flexibility;
- 4) excellent dehydration properties;
- 5) high boiling point; and
- 6) good catalytic properties.

In addition, sulphur forms intermediate products (organic sulfates, for example) which are easily formulated into other, final products. (S6)

2.0 PRODUCTION STATUS IN NEW BRUNSWICK

Sulphur is recovered as a secondary product from two operations in the Province: the Brunswick Mining and Smelting Corporation (Smelting and Fertilizer Division) operation at Belledune, and the Irving Oil Limited refinery in Saint John.

Production of sulphuric acid at the Belledune smelter began in 1967. The smelting process results in the production of sulphur dioxide gas (SO_2). Environmental regulations limit the release of these gases into the atmosphere and the recovery of sulphur products provides a level of offsetting income against the costs of emission control. The sulphur dioxide gas is cleaned of particulate matter using an electrostatic precipitator. The gas is then cooled and dried in the acid plant to produce sulphuric acid (H_2SO_4).

Sulphuric acid in the order of 94 percent strength is shipped to the nearby fertilizer operation where it is used to produce diammonium phosphate. Table 1 and Figure 1 provide summaries of sulphur production from smelter gas in the Province (i.e., sulphuric acid expressed in tonnes of equivalent sulphur).

Sulphur is also recovered from crude oil during the refining process. Sulphur content varies depending on the source region of the crude. A hydrogenation process is used to convert organic sulphur compound in the crude to hydrogen sulphide (H_2S).

Until the early 1970s, this toxic gas was combusted as part of the fuel used by the refining process itself. More stringent environmental regulations on sulphur emissions have reduced this practice. The hydrogen sulphide is now converted to sulphur by the Claus process which was developed in 1885. The H_2S is burned under controlled conditions so that about one-third is

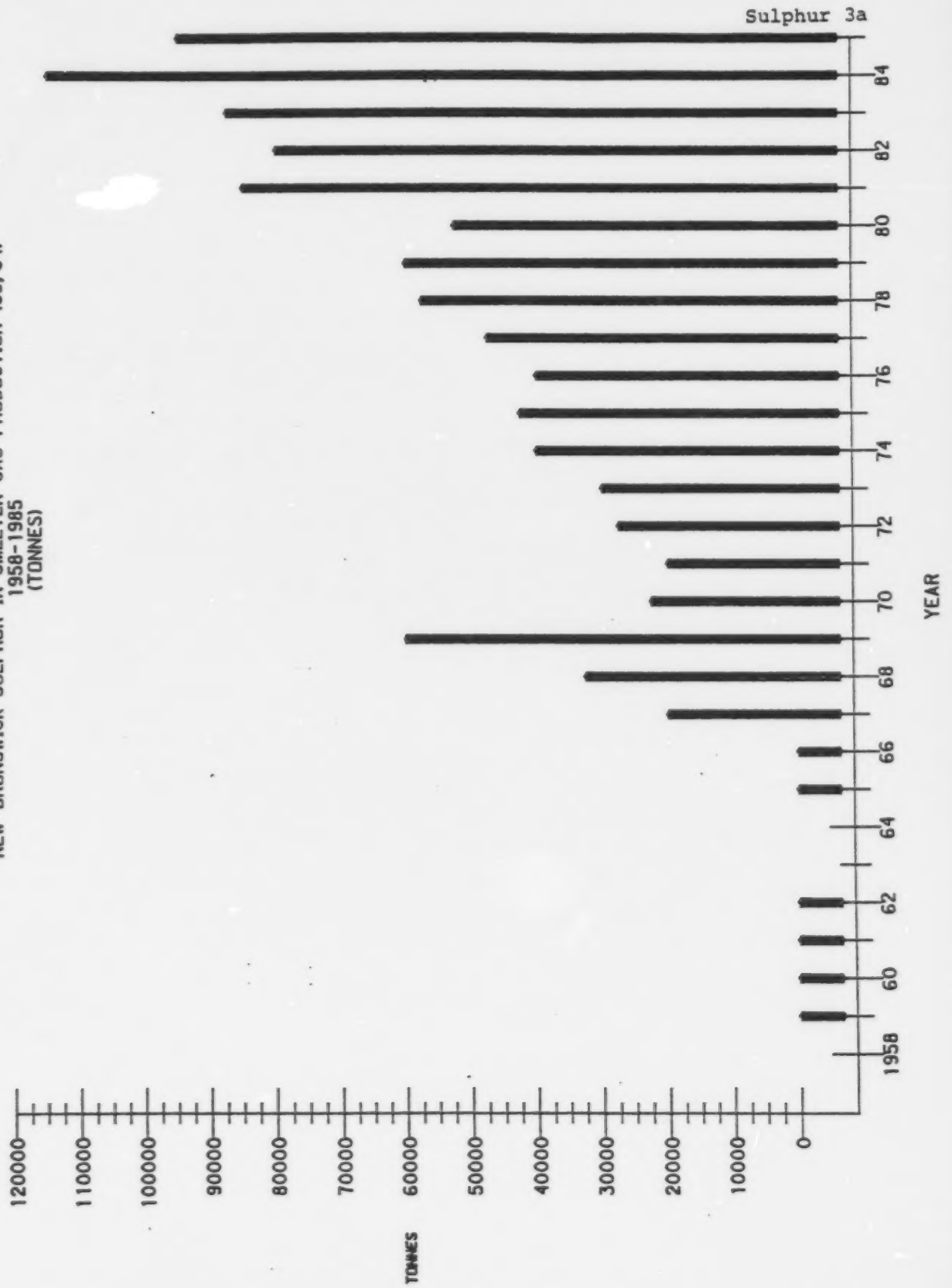
TABLE 1

NEW BRUNSWICK SULPHUR IN SMELTER GAS PRODUCTION (S3, S4)
1958-1987

<u>Year</u>	<u>Tonnes (Thousands)</u>	<u>Current Dollars (Thousands)</u>	<u>1987 Dollars (Thousands)</u>
1958	N/A	\$ 23	\$ 104
1959	0	0	0
1960	0	0	0
1961	0	0	0
1962	0	0	0
1963	N/A	16	68
1964	N/A	17	71
1965	0	0	0
1966	0	0	0
1967	20 871	226	858
1968	32 668	531	1 937
1969	60 799	896	3 129
1970	22 686	231	781
1971	19 964	168	552
1972	28 131	232	728
1973	29 946	440	1 281
1974	36 298	635	1 721
1975	42 650	586	1 389
1976	39 020	781	1 722
1977	46 279	1 211	2 473
1978	57 169	1 155	2 167
1979	60 799	1 264	2 173
1980	52 000	1 341	2 089
1981	85 000	5 478	7 595
1982	80 000	3 328	3 914
1983	88 000	3 825	4 525
1984	114 000	8 507	9 644
1985	92 000	11 175	12 678
1986	84 000	8 956	9 314
1987p	91 000	11 140	11 140

NA - data not available

FIGURE 1
NEW BRUNSWICK SULPHUR IN SMELTER GAS PRODUCTION (S3, S4)
1958-1985
(TONNES)



converted to sulphur dioxide (SO_2). The remaining H_2S and the SO_2 react in the presence of a catalyst to produce sulphur and water. Over 90 percent of the sulphur is removed by this process. The sulphur leaves the reaction vessel in a liquid (molten) form. While it can be shipped in this form, it is common practice to pour the sulphur on the ground (in forms) and allow it to solidify. In this dry state it can be stored indefinitely. (S5)

The Irving Oil Limited refinery in Saint John produces in the order of 220 tonnes per day of sulphur. The material is marketed primarily to pulp mills in the Maritimes and north-eastern United States.

3.0 CONSUMPTION

Uses and quantities. Almost all the sulphur consumed in Canada is in the form of sulphuric acid. Table 2 presents the consumption of sulphuric acid in Canada for 1985. The main uses were fertilizers (68.6%), uranium mines (10.1%) and pulp and paper mills (11.5%). (S1) (See Figure 2.)

The consumption of sulphur in the United States is presented in Table 3. The top uses are: phosphatic fertilizers (58.4%), petroleum refining (7.9%), and agricultural chemicals (4.8%). (S2)

3.1 Phosphatic Fertilizer

Description. Sulphuric acid is used in the wet phosphoric acid process to digest phosphate rock ($\text{CaF}_2 \cdot 3\text{Ca}_3(\text{PO}_4)_2$) and produce phosphoric acid (H_3PO_4). Phosphoric acid is an intermediate product used to produce a series of fertilizers. One of the major by-products of the wet phosphoric acid process is gypsum. (S7)

Companies and locations. Sulphuric acid is easier to transport than phosphate rock; for this reason, most phosphatic fertilizer is produced near phosphate rock mine sites. In North America phosphate rock is mined in Florida, North Carolina, Idaho, Utah and Tennessee and most of it is consumed either within those or adjacent states. However, some phosphate rock is exported, notably to:

FIGURE 2

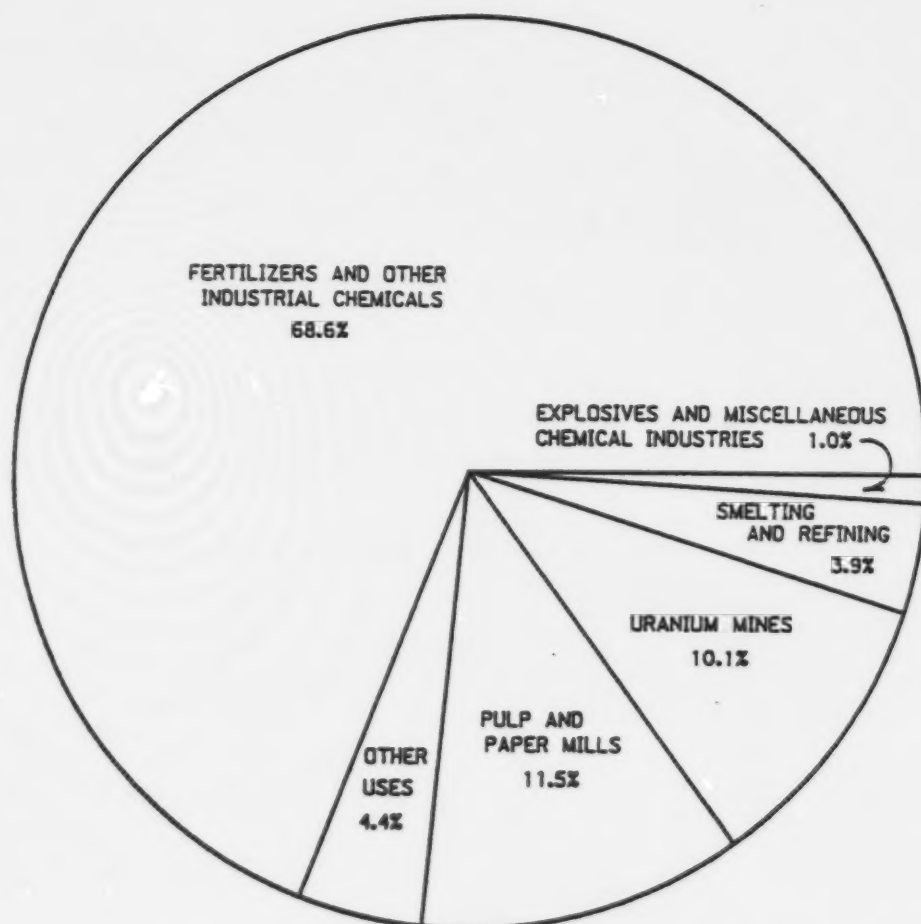
CONSUMPTION OF SULPHURIC ACID
IN CANADA, IN 1985 (SI)

TABLE 2
CONSUMPTION OF SULPHURIC ACID IN CANADA, 1985 (\$1)

Use	Quantity Tonnes (M)	%
Fertilizers and other industrial chemicals	2.300	68.6
Pulp and paper mills	0.386	11.5
Uranium mines	0.339	10.1
Smelting and refining	0.130	3.9
Explosives and miscellaneous chemical industries	0.035	1.0
Petroleum refineries and coal products	0.028	0.8
Leather industries	0.021	0.6
Other end uses	0.021	0.6
Miscellaneous metal mines	0.020	0.6
Electrical product industries	0.020	0.6
Miscellaneous manufacturing industries	0.017	0.5
Soap and clearing compounds	0.011	0.3
Iron and steel mills	0.008	0.2
Sugar, vegetable oil and miscellaneous food processors	0.006	0.2
Plastics and synthetic resins	0.001	**
Total	3.353	100.0

TABLE 3

SULPHUR AND SULPHURIC ACID SOLD OR USED
IN THE UNITED STATES IN 1986 (\$2)

Use	Elemental Sulphur (tonnes) (M)	Sulphuric Acid (sulphur equivalent) (tonnes) (M)	Total (tonnes) (M)	%
Phosphatic fertilizers	—	6.339	6.339	58.4
Petroleum refining and other petroleum and coal products	0.084	0.777	0.861	7.9
Other agricultural chemicals	0.501	0.024	0.525	4.8
Other inorganic chemicals	0.069	0.272	0.341	3.1
Industrial organic chemicals	—	0.289	0.289	2.7
Copper ores	—	0.246	0.246	2.3
Pulp mills and paper products	0.019	0.223	0.242	2.2
Synthetic rubber and other plastic materials and synthetics	W	0.227	0.227	2.1
Inorganic pigments, paints and allied products, industrial organic chemicals, other chemical products	0.017	0.108	0.125	1.2
Soaps and detergents	0.047	0.069	0.116	1.1
Water treating compounds	—	0.110	0.110	1.0
Nitrogenous fertilizers	—	0.075	0.075	0.7
Steel pickling	—	0.063	0.063	0.6
Storage batteries (acid)	—	0.045	0.045	0.4
Cellulose fibres, including rayon	—	0.041	0.041	0.4
Other chemical products	—	0.041	0.041	0.4
Nonferrous metals	—	0.031	0.031	0.3
Uranium and vanadium ores	—	0.029	0.029	0.3
Explosives	—	0.027	0.027	0.3

TABLE 3 (continued)

Use	Elemental Sulphur (tonnes) (M)	Sulphuric Acid (sulphur equivalent) (tonnes) (M)	Total (tonnes) (M)
Other ores	—	0.024	0.024
Pesticides	—	0.022	0.022
Drugs	—	0.015	0.015
Other primary metals .	—	0.012	0.012
Exported sulphuric acid	—	0.011	0.011
Rubber and miscellaneous plastic products	—	0.003	0.003
Food and kindred products	W	—	W
Total identified	0.737	9.122	9.859
Unidentified	0.564	0.440	1.004
TOTAL	1.301	9.562	10.863

Brunswick Mining and Smelting Corp. Ltd. (Fertilizer Division)

- division of Noranda Inc.
- Belledune, N. B.
- annual capacity of 150 000 tonnes of P_2O_5 equivalent
- sulphuric acid derived from SO_2 smelter gas

C-I-L Inc.

- Courtright, Ont.
- annual capacity of 90 000 tonnes of P_2O_5 equivalent (now shut down)
- sulphuric acid from SO_2 smelter gas, pyrrhotite roast, and waste acid.

Sources and suppliers. Canadian producers of sulphur and sulphuric acid within 800 kilometres of New Brunswick are listed in Table 4. There are no large American producers of sulphur known within 800 kilometres of New Brunswick.*

Specifications.

Sulphuric acid is generally reported as 100 percent H_2SO_4 . Pure sulphuric acid contains 32.7 percent sulphur.

Elemental sulphur contains at least 99.5 percent sulphur. The term covers most sulphur produced from frash, recovered, or by-product sources.

Prices. In Canada most prices are quoted FOB Vancouver; in the United States various locations are used (Tampa, New Orleans). Table 5 quotes prices for both Canada and the United States.

*There are two smelters, one at Monaca, PA (zinc) and Carteret, NJ (copper) and several refineries, but none are known to have sulphur recovery.

TABLE 4

PRODUCERS OF SULPHUR, SULPHUR DIOXIDE AND SULPHURIC ACID
WITHIN 800 KILOMETRES OF NEW BRUNSWICK (S1)

Industry	Company	Location	Annual Capacity, tonnes (M) (Sulphur equivalent)	Notes
Smelting	Brunswick Mining and Smelting Corporation Limited	Belledune, N.B.	0.052	- supplies Belledune Fertilizer - acid producer - lead and zinc smelter
	Canadian Electrolytic Zinc Limited	Valleyfield, Que.	0.144	- acid producer - zinc concentrator
	Gaspé Copper Mines Limited	Murdochville, Que.	0.052	- now closed - acid producer - copper smelting
Acid Producing	C-I-L Inc.	Beloeil, Que.	0.021	- acid from elemental sulphur
	NL Chem Canada Inc.	Varennnes, Que.	0.018	- acid from elemental sulphur
Petroleum Refinery	Irving Oil Limited	Saint John, N.B.	0.110	
	Imperial Oil Limited	Dartmouth, N.S.	0.028	
	Canadian Ultramar	St. Romuald, Que.	0.030	
	Gulf Canada Limited	Clarkson, Ont.	0.018	
	Petro-Canada	Oakville, Ont.	0.015	
TOTAL	-	-	0.488	-

TABLE 5
DECEMBER 1988 PRICES FOR SULPHUR (\$10)

TYPE	PRICE (\$CDN/TONNE)
Sulfur, crude, bright, molten, domestic, f.o.b. Port Sulfur	\$161
recovered, delivered, Houston	\$145 - \$160
received, delivered, New Orleans	\$148 - \$160
exterminal, Rotterdam	\$165
f.o.b. tanks, Alberta, for U.S. delivery	\$ 81 - \$ 88
f.o.b. Vancouver	\$138 - \$142
dark, ex. - Tampa, Florida	\$192
Sulfur, crude, 99.5% minimum purity	\$405
commercial flour 22.5 kg bags,	
carload, mines basis	
lump, same basis	\$405
Sulfur, refined, 99.5% minimum purity	\$520
rolls 22.4 kg bags	
carload, mines basis	
flour, light, 22.5 kg bags, same basis	\$596
Sulfur, refined, sublimed, N.F., 99.85%	\$775
minimum purity, 22.5 kg bags,	
carload, mines basis	
Sulfur, rubbermakers, 99.5% minimum	\$465
purity, commercial reg., 22.5 kg bags,	
carload, mines basis	
fine, 98% minimum passing through mesh,	\$495
same basis	

Substitutes. There is no economic substitute for sulphuric acid in the wet phosphoric acid process. There is a nitric acid acidulation process for phosphate rock which produces a fertilizer richer in nitrogen. However, the wet phosphoric acid process remains the most popular means of treating phosphate rock because of the lower price for sulphuric acid relative to nitric acid.

3.2 Pulp and Paper Mills

Description. The primary use of sulphur in the pulp and paper industry is in the sulfite pulping process. The form of sulphur used is sulphur dioxide which is generally formed by burning elemental sulfur. The sulphur dioxide** is mixed with magnesium oxide (in older mills, calcium oxide) forming magnesium bisulfite; this compound dissolves wood lignin leaving cellulose for paper production. Modern practice favours the magnesium-sulfite process because much of the magnesium and sulphur is recoverable thus reducing chemical costs and water pollution. (S9)

Sulphuric acid is also used in the pulp and paper industry as a bleaching agent.

Companies and locations. A list of sulfite mills (bleached and unbleached) and sulfate mills (bleached and unbleached) within 800 kilometres of New Brunswick is presented in Table 6 and Table 7, respectively.

**About 4.5 percent total sulphur dioxide and 3.5 percent "free" sulphur dioxide

TABLE 6

BLEACHED AND UNBLEACHED SULFITE PULP MILLS
WITHIN 800 KILOMETRES OF NEW BRUNSWICK (S10)

<u>Province/State</u>	<u>Company</u>	<u>Location</u>	<u>Capacity (tonnes/day)</u>
New Brunswick	Fraser Inc.	Edmundston	360 (bleached)
	Fraser Inc.	Edmundston	180 (unbleached)
	Atholville Pulp, Inc.	Atholville	360 (bleached)
	NBIP Ltd.	Dalhousie	180 (unbleached)
Newfoundland	Abitibi-Price Inc.	Grand Falls	210 (unbleached)
	Corner Brook Pulp and Paper Ltd.	Corner Brook	210 (unbleached/ semi-bleached)
	Bowater Mersey Paper Co. Ltd.	Liverpool	145 (unbleached)
Nova Scotia	Stora Forest Industries	Port Hawkesbury	455 (bleached)
	Price Co. Ltd.	Beaupre	110 (unbleached)
Quebec	CIP Inc.	Trois Rivières	220 (unbleached)
	Consolidated-Bathurst Inc.	Grand Mere	135 (unbleached)
	Consolidated-Bathurst Inc.	Shawinigan	295 (unbleached)
	Consolidated-Bathurst Inc.	Ville de la Baie	220 (unbleached)

Sulphur

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TABLE 6 (continued)

Province/State	Company	Location	Capacity (tonnes/day)
Quebec (continued)	Domtar Inc.	Dolbeau	180 (unbleached)
	Donohue Inc.	Clermont	135 (unbleached)
	Gaspesia Pulp & Paper Co. Ltd.	Chandler	135 (unbleached)
	James MacLaren Industries Inc.	Masson	250 (unbleached)
	Kruger Inc.	Trois Rivières	230 (unbleached)
	The Price Co. Ltd.	Alma	200 (bleached)
	Quebec & Ontario Paper Co. Ltd.	Baie Comeau	360 (unbleached)
	Rayonier Quebec Inc.	Port Cartier	680 (bleached)
	Reed Paper Ltd.	Quebec City	455 (unbleached)
	St. Raymond Paper Inc.	Desbiens	110 (unbleached)
	Tembec Inc.	Temiscaming	635 (bleached)
	Abitibi-Price Inc.	Iroquois Falls	270 (bleached and unbleached)
	Abitibi-Price Inc.	Thunder Bay	115 (unbleached)
Ontario	Boise Cascade Canada Ltd.	Kenora	220 (unbleached)
	Quebec & Ontario Paper Co. Ltd.	Thorold	220 (unbleached)
	Spruce Falls Power & Paper Co. Ltd.	Kapuskasing	180 (unbleached)

TABLE 6 (continued)

<u>Province/State</u>	<u>Company</u>	<u>Location</u>	<u>Capacity (tonnes/day)</u>
Ontario (continued)	The Great Lakes Forest Products Ltd.	Thunder Bay	1280 (bleached)
Maine	Great Northern Paper Co.	Millinocket	645 (unbleached)
Massachusetts	Rising Paper Co.	Housatonic	45 (bleached)
New York	Finch, Pruyn & Co. Inc.	Glens Falls	345 (bleached)
Pennsylvania	Proctor & Gamble Paper Products Co.	Mehoopany	Not available (bleached)

TABLE 7

BLEACHED AND UNBLEACHED SULFATE MILLS
WITHIN 800 KILOMETRES OF NEW BRUNSWICK (\$10)

<u>Province/State</u>	<u>Company</u>	<u>Location</u>	<u>Capacity (tonnes/day)</u>
New Brunswick	Miramichi Pulp & Paper Inc.	Newcastle	600 (bleached)/ unbleached)
	Irving Pulp and Paper Ltd.	Saint John	745 (bleached)
	St. Anne Nackawic Pulp & Paper Co. Ltd.	Nackawic	680 (bleached)
Nova Scotia	Scott Maritimes Ltd.	Abercrombie Point	545 (bleached)
Quebec	Cascades (Jonquiere) Inc.	Jonquiere	180 (bleached)
	Cascades (East Angus) Inc.	East Angus	180 (unbleached)
	CIP Inc.	La Tuque	420 (bleached)
	Consolidated Bathurst Inc.	Portage-du-Fort	570 (bleached)
	Consolidated Bathurst Inc.	New Richmond	645 (unbleached)
	Consolidated Bathurst Inc.	Trois Rivières	270 (unbleached)

Sulphur

TABLE 7 (continued)

<u>Province/State</u>	<u>Company</u>	<u>Location</u>	<u>Capacity (tonnes/day)</u>
Quebec (continued)	Domtar Inc.	Lebel-Sur-Quevillon	750 (bleached/ (unbleached)
	Domtar Inc.	Windsor	360 (bleached) 55 (unbleached)
	Donohue St.-Felicien Inc.	St.-Felicien	730 (bleached)/ (unbleached)
	James MacLaren Industries Inc.	Thurso	330 (bleached)
	St. Raymond Paper Ltd.	Saint Raymond	145 (bleached)
Ontario	Abitibi-Price Inc.	Smooth Rock Falls	290 (bleached)
	Boise Cascade Canada Ltd.	Fort Frances	465 (bleached)
	Domtar Inc.	Cornwall	410 (bleached)
	Domtar Inc.	Red Rock	45 (bleached) 659 (unbleached)
	E.B. Eddy Forest Products Ltd.	Espanola	733 (bleached/ (unbleached)
	Great Lakes Forest Products Ltd.	Thunder Bay	1288 (bleached)
	Great Lakes Forest Products Ltd.	Dryden	655 (bleached)
	James River-Marathon Ltd.	Marathon	455 (bleached)

Sulphur

TABLE 7 (continued)

<u>Province/State</u>	<u>Company</u>	<u>Location</u>	<u>Capacity (tonnes/day)</u>
Ontario (continued)	Kimberly-Clark of Canada Ltd.	Terrace Bay	1135 (bleached)
Maine	Boise Cascade Corp.	Rumford	590 (bleached)
	Georgia-Pacific Corp.	Woodland	730 (bleached)
	International Paper Co.	Jay.	1020 (bleached)
	Madison Paper Industries	Madison	345 (bleached)
	Lincoln Pulp & Paper Co.	Lincoln	320 (bleached)
New Hampshire	Scott Paper Co.	Hinckley	820 (bleached)
	S.D. Warren Co.	Westbrook	270 (bleached)
	James River Corp.	Berlin	730 (bleached/ unbleached)
New York	International Paper Co.	Ticonderoga	480 (bleached)
Pennsylvania	Appleton Paper Inc.	Roaring Spring	165 (bleached)
	The P.H. Glatfelter Co.	Spring Grove	500 (bleached)
	Pennntech Papers Inc.	Johnsonburg	200 (bleached)

Sources and suppliers. Sulphur suppliers for the pulp and paper industry are presented below (S10):

Bethlehem Steel Corp., Bethlehem, PA
Delta Chemicals Inc., Searsport, ME
Mobil Oil Corp., Fairfax, VA
New England Chemical Co., Merrimack, NH
Smith Chemical & Color Co. Inc., Jamaica, NY
Stauffer Chemical Co. Basic Products Group, Westport, CT

Specifications. As elemental sulphur only purity specifications are required. For acid, the concentration is required.

Prices. As discussed in Section 3.1.

Substitutes. There are several alternatives to the sulfite pulping process including the groundwood, kraft (or sulfate) and semichemical processes. Selection of a process is dependent upon the type of wood fibre available, paper product desired, chemical costs, pollution control costs, energy cost and other factors. At the present the sulfite process is holding its own, but the trend towards increased chemical recycling could reduce sulphur demand for the process. (S9)

3.3 Uranium Recovery

Description. Sulphuric acid is used to leach uranium from ore. The resultant solvent is then concentrated into "yellow cake". Further processing using chemicals (caustic soda, sodium chlorate, and others) and ion exchange is used to further concentrate the uranium. (S7)

Companies and locations. There are uranium deposits but no uranium mines within 800 kilometres of New Brunswick.

Sources and suppliers. See Sections 3.1 and 3.2.

Specifications. See Sections 3.1 and 3.2.

Prices See Sections 3.1 and 3.2.

Substitutes. Sulphuric acid is the main chemical used for uranium ore leaching and is likely to remain so because of its low price and easy availability.

3.4 Petroleum Refining

Description. Sulphuric acid is used for a number of processes in petroleum refining and associated chemical processing. The largest single use is as a catalyst for the alkylation process--the formation of high-octane gasoline. As a catalyst the acid can be reclaimed for reuse in the process, for this reason most acid is purchased for makeup - about 30 percent of acid flow in a refinery each year. (S7)

Companies and locations. The names and locations of petroleum refineries within 800 kilometres of New Brunswick are listed in Table 8.

Sources and suppliers. Many of those refineries are themselves sources of sulphur and sulphuric acid. Makeup sulphur would come from sources listed in Table 4 or from outside the region (western Canada, southern United States).

Specifications. See Sections 3.1 and 3.2.

Prices. See Sections 3.1 and 3.2.

Substitutes. In chemical processing sulphuric acid can be replaced by hydrochloric or nitric acids. However, sulphuric acid is generally cheaper and has an additional process

TABLE 8

PETROLEUM REFINERIES WITHIN 800 KILOMETRES OF NEW BRUNSWICK
(TRADE DIRECTORIES)

<u>Province/State</u>	<u>Location</u>	<u>Company</u>
New Brunswick	Saint John	Irving Oil Ltd., Refining Div.
Nova Scotia	Dartmouth	Imperial Oil Ltd.
	Dartmouth	Texaco Canada Inc. Halifax Refinery
Ontario	Downsview	Imperial Oil Ltd.
	Oakville	Petro Canada Inc.
	Oakville	Shell Canada Limited
	London	Suncor Inc.
	Toronto	Sunoco Inc.
	Mississauga	Texaco Canada Inc.
	Don Mills	Ultramar Canada Inc.
Quebec	Montreal	Gulf Canada Limited
	Montreal	Imperial Oil Limited
	Pointe-Aux-Trembles	Petro Canada Products Inc.
	Montreal	Shell Canada Limited
	St. Romuald-D'Etchemin	Ultramar Canada Inc.
Connecticut	Torrington	Patterson Oil Company
Massachusetts	Quincy	Quinoil Industries Inc.
New Jersey	Middlesex County	Chevron USA Inc.
	Union County	Exxon Co. USA
	Gloucester County	Mobile Oil Corp.
	Gloucester County	Texaco Inc.
New York	Tonawanda, Erie County	Ashland Petroleum, Div. of Ashland Oil Inc.
Pennsylvania	Philadelphia	Atlantic Richfield Co. Point Breeze Refinery
	Marcus Hook, Delaware County	B.P. Oil Inc.
	Bradford, McKean County	Quaker State Oil Refining Corp., McKean Refinery

advantage: a large volume of steam is produced in the production of sulphuric acid. This steam is an energy source which can be used for other chemical processes or to generate electricity.

3.5 Consumption Estimates

Phosphatic fertilizer. The only fertilizer plant in the extended market area (the Atlantic Provinces, the Gaspé, Maine) is the Brunswick Mining and Smelting Corp. Ltd. plant at Belledune. It uses the entire production of sulphuric acid from the nearby smelter (80 000 - 115 000 tonnes).

Pulp and paper mills. Sulphur is primarily used in the sulfite pulping process where it is burnt to produce sulfur dioxide for digesting liquor. Recent advances in pulping technology have reduced the number of sulfite mills and the quantity of sulphur consumed in the sulfite process.

The Irving Oil Limited refinery in Saint John provides sulphur to most of the sulfite and sulfate (bleaching) mills in the extended market area. It produces 220 tonnes of sulphur per day (80 000 tonnes per year). Another source is the Imperial Oil Limited refinery in Dartmouth (20 000 tonnes per year).

Oil refineries. There are four oil refineries in the extended market area (Saint John, Dartmouth (2), Come-By-Chance). Most refineries produce their own sulphuric acid with makeup (say 5000 tonnes) purchased from Irving Oil, Imperial Oil (Dartmouth) or another source.

Total. Estimated sulphuric acid consumption in the extended market area:

Phosphatic fertilizer	80 000 - 115 000 tonnes
Pulp and paper	80 000
<u>Oil refining</u>	<u>20 000</u>
	180 000 - 215 000 tonnes

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